Climate change

Tropical flip-flop connections

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A long climatic record shows that episodic wet periods in northeastern Brazil are linked to distant climate anomalies. The ocean–atmosphere system can evidently undergo rapid and global reorganization.

Every few years, the semi-arid but densely populated region of northeastern Brazil experiences severe drought. In 1997–98, exacerbated by poor distribution of resources, such an event caused great hardship. And in the catastrophic drought of 1877–79, hundreds of thousands of people perished. The causes of these conditions are neither accidental nor local, but part of an orchestrated sequence of large-scale atmospheric and oceanic processes over the entire tropical Atlantic (Fig. 1). These processes lead to changes in the seasonal southward migration of the Intertropical Convergence Zone (ITCZ)[1], the rainfall band that spans the Atlantic. When the southward migration of the ITCZ in February–May stops short of northeastern Brazil, the rainy season fails.

For those seeking knowledge of past climate changes, however, northeastern Brazil presents an opportunity: what better place to focus on than one where flip-flopping climate is singularly representative of changes throughout the entire tropical Atlantic? Wang *et al.* (page 740 of this issue)[2] have done just that. They find that over the past 210,000 years northeastern Brazil underwent episodic changes from its usual semi-arid state to a wetter climate, implying a persistently southward-shifted ITCZ. Unlike the present-day disturbances, which last a few years at most, these past wet episodes typically persisted for several centuries. The authors deduced the presence and duration of the wet periods from the growth patterns and ages of mineral deposits, called speleothems and travertines, in the northern part of Bahia state in Brazil.

Speleothems are deposited in caves, and travertines along spring-fed rivers and streams, when calcium carbonate precipitates out of supersaturated ground and spring waters; deposition is a good indicator of abundant rainfall. Northeastern Brazil is usually too arid to support the formation of either type of deposit (as is the case for present-day conditions), but repeated episodes of persistently wetter conditions evidently allowed them to form in the past. The remains of vegetation embedded in the travertines show that semi-deciduous forest abounded during the wet phases, linking the Amazon rainforest in the northwest with the Atlantic rainforest along the eastern coast of Brazil. An intriguing idea put forward by Wang *et al.* is that the unusual biodiversity of these rainforests can be attributed partly to the floristic exchange made possible by the recurring shifts to a wet climate.

The more remarkable aspect of this study, however, is identification of the apparent synchrony of wet periods in northeastern Brazil with climate changes near and far. The timing of the wet periods can be accurately determined using uranium–thorium dating, a system that relies on decay products of radioactive uranium-238. The ages of speleothems analysed by Wang *et al.* correlate remarkably well with the timing of climate changes in different parts of the Northern Hemisphere — specifically, with weakening of the East Asian summer monsoon; with cold periods over Greenland; and with episodes in the North Atlantic, known as Heinrich events, that are characterized by massive release of icebergs into the open ocean from continental glaciers. Closer to home, Wang and colleagues' results elegantly confirm earlier indications of a southward-displaced ITCZ deduced from mineralogical changes in sediments of the Cariaco Basin, off Venezuela[3].

What do these records tell us about the climate system? Cold episodes over the

Plant biochemistry

Green catalytic converter

A key component of the Kyoto Protocol — the international agreement that aims to reduce greenhouse-gas concentrations — is the control of carbon emissions into the atmosphere. This will require industries to reclaim and recycle the carbon dioxide they currently discard. Elsewhere in this issue (see *Nature* **432,** 779–782; 2004), Jörg Schwender and colleagues show that plants are way ahead of us in this respect.

Oil is the major storage product in most seeds, but the standard biochemical route for its synthesis was thought to be quite wasteful. Plants employ a variation of glycolysis, the metabolic pathway also used by animals, which breaks down glucose to produce energy. One of its end products is pyruvate, which can be converted to acetyl-CoA, a precursor for fatty acids and oils. This reaction also produces CO_2. For every two carbon atoms that are made into oil, at least one should be lost as gas.

Schwender *et al.* found that oil production in seeds of *Brassica napus* (oilseed rape or canola; shown here) was nowhere near as inefficient. Using radioactive labelling, they measured the ratio of carbon used to carbon lost as almost three to one. Closer investigation showed that these savings are achieved by a previously unsuspected function of probably the most abundant protein in the world, Rubisco.

Rubisco catalyses a critical reaction in photosynthesis. It combines CO_2 with the sugar ribulose 1,5-bisphosphate to produce two molecules of phosphoglyceric acid as part of a complicated series of chemical reactions known as the Calvin cycle. It turns out that rape seeds have high levels of Rubisco, but no detectable Calvin-cycle activity. Instead, the enzyme's supply of ribulose 1,5-bisphosphate is synthesized afresh from fructose and glyceraldehydes, allowing it to soak up the CO_2 produced from making acetyl-CoA. The resulting pyruvate is then used to make more oil.

Not all seeds can reclaim CO_2 in this way; sunflower seeds, for example, are much less efficient in their oil production. The difference is that growing *Brassica* seeds are green. Despite being enclosed in a pod, enough light filters through to be captured by the pigment chlorophyll, supplying the energy needed for the synthesis of ribulose. In seeds, at least, it is only the greens that recycle. **Christopher Surridge**